

1           BENCH ASSEMBLY AND BI-DIRECTIONAL OPTICAL TRANSCEIVER  
2                           CONSTRUCTED THEREWITH

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4                           CROSS-REFERENCE TO RELATED APPLICATIONS

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6           This application claims the benefit of United States  
7   Provisional Application Serial No. 60/412,256, filed September  
8   23, 2002.

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10                          FIELD OF THE INVENTION

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12           This invention relates to optical transceivers and, more  
13   particularly, to packaged optical transceivers.

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18                          BACKGROUND OF THE INVENTION

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20           Optical fibers are useful in high-speed data transmission  
21   systems.   These high-speed systems can include an optical  
22   fiber optically coupled to a module which includes a light  
23   emitting or light detecting device.   A module with a light

1 emitting device is typically referred to as a transmitter  
2 module wherein an electrical signal is converted to a light  
3 signal which is emitted by the light emitting device and is  
4 incident to the optical fiber. A module with a light  
5 detecting device is typically referred to as a receiver module  
6 wherein an optical signal is converted to an electrical  
7 signal.

8  
9 It is important to minimize the cost of the components  
10 included in fiber optic systems. In the prior art, the high  
11 cost of transceivers built with existing technology makes it  
12 cost prohibitive to undertake installation of extensive fiber  
13 networks with individual connections. Thus, it is highly  
14 desirable to provide a cost effective optical package which is  
15 capable of transmitting and receiving data in a fiber to a  
16 home network.

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SUMMARY OF THE INVENTION

The above problems and others are at least partially solved and the above purposes and others realized in a preferred apparatus embodiment including a header having a surface defining a substantially horizontal plane, and a chip-level optical transceiver carried by a bench disposed in a tilted state for aligning the chip-level optical transceiver with an optical fiber. In a particular embodiment, an optical fiber is aligned with the chip-level optical transceiver. Preferably, a package secures and contains the optical fiber, the bench, and the chip-level optical transceiver carried by the bench. The package includes a support structure securing the fiber, and a header coupled to the support structure, in which the bench is carried by the header in front of the optical fiber. Preferably, the package hermetically seals the bench and the chip-level optical transceiver carried thereby. The chip-level optical transceiver includes a light emitting device, having an output, for emitting a first wavelength of light along a first optical path, a first photodiode for controlling the output of the light emitting device, a second photodiode having an active region, a lens for receiving the first wavelength of light along the first optical path from

1 the light emitting device and collimating the first wavelength  
2 of light to the second photodiode along the first optical  
3 path, and the second photodiode for reflecting the first  
4 wavelength of light along the first optical path into the  
5 optical fiber along a second optical path. The optical fiber  
6 is operative for transmitting a second wavelength of light to  
7 the second photodiode along the second optical path. The  
8 second photodiode adapted and arranged to permit the second  
9 wavelength of light to pass therethrough to the active region  
10 thereof for conversion into an electrical signal. The first  
11 wavelength of light is different from the second wavelength of  
12 light, and the first optical path is coincident to the second  
13 optical path.

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15 In an optical fiber and a header mounted adjacent the  
16 optical fiber, the invention also provides apparatus therein  
17 consisting of a chip-level optical transceiver supported by a  
18 bench carried by the header in a tilted state aligning the  
19 chip-level optical transceiver components with the optical  
20 fiber. Preferably, a package secures and contains the optical  
21 fiber, the bench, and the chip-level optical transceiver  
22 carried by the bench. The package includes a support  
23 structure securing the fiber, and a header coupled to the

1 support structure, in which the bench is carried by the header  
2 in front of the optical fiber. Preferably, the package  
3 hermetically seals the bench and the chip-level optical  
4 transceiver carried thereby. The chip-level optical  
5 transceiver includes a light emitting device, having an  
6 output, for emitting a first wavelength of light along a first  
7 optical path, a first photodiode for controlling the output of  
8 the light emitting device, a second photodiode having an  
9 active region, a lens for receiving the first wavelength of  
10 light along the first optical path from the light emitting  
11 device and collimating the first wavelength of light to the  
12 second photodiode along the first optical path, and the second  
13 photodiode for reflecting the first wavelength of light along  
14 the first optical path into the optical fiber along a second  
15 optical path. The optical fiber is operative for transmitting  
16 a second wavelength of light to the second photodiode along  
17 the second optical path. The second photodiode adapted and  
18 arranged to permit the second wavelength of light to pass  
19 therethrough to the active region thereof for conversion into  
20 an electrical signal. The first wavelength of light is  
21 different from the second wavelength of light, and the first  
22 optical path is coincident to the second optical path.

1        In accordance with the principle of the invention,  
2 further provided is a method comprising steps of providing an  
3 optical fiber, providing a bench that supports a chip-level  
4 optical transceiver, placing the bench in front of the optical  
5 fiber, activating the chip-level optical transceiver, and  
6 tilting the bench until the chip-level optical transceiver is  
7 aligned with the optical fiber and an optical signal is  
8 achieved. Further to the method is the step of mounting the  
9 optical fiber, the bench, and the chip-level optical  
10 transceiver carried by the bench in a package. The package  
11 includes a support structure securing the fiber, and a header  
12 coupled to the support structure, in which the bench is  
13 carried by the header in front of the optical fiber. The  
14 chip-level optical transceiver includes a light emitting  
15 device, having an output, for emitting a first wavelength of  
16 light along a first optical path, a first photodiode for  
17 controlling the output of the light emitting device, a second  
18 photodiode having an active region, a lens for receiving the  
19 first wavelength of light along the first optical path from  
20 the light emitting device and collimating the first wavelength  
21 of light to the second photodiode along the first optical  
22 path, and the second photodiode for reflecting the first

1 wavelength of light along the first optical path into the  
2 optical fiber along a second optical path.

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4 In accordance with the foregoing summary of preferred  
5 embodiments, and the ensuing specification, which are intended  
6 to be taken together, the invention also contemplates  
7 associated apparatus and method embodiments.

1 BRIEF DESCRIPTION OF THE DRAWINGS

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3 Referring to the drawings:

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5 FIG. 1 is a simplified, vertical sectional view of an  
6 integrated transceiver package incorporating a tilted bench  
7 assembly supporting chip-level optical transceiver components,  
8 in accordance with the principle of the invention; and

9

10 FIG. 2 is a simplified, vertical sectional view of the  
11 tilted bench assembly of FIG. 1 carried by a header and  
12 disposed in optical alignment with an optical fiber.



1            DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

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3            An integrated bi-directional transceiver is disclosed,  
4    which includes a package that incorporates a header.    An  
5    optical fiber extends into the package, and is secured thereby  
6    adjacent the header.    A chip-level optical transceiver is  
7    supported by a bench carried by the header in a tilted state  
8    aligning the chip-level optical transceiver components with  
9    the optical fiber.    Also disclosed in this specification is a  
10   header having a surface defining a substantially horizontal  
11   plane, and a chip-level optical transceiver carried by a bench  
12   disposed in a tilted state for aligning the chip-level optical  
13   transceiver with an optical fiber.    In an optical fiber and a  
14   header mounted adjacent the optical fiber, this disclosure  
15   still further provides improvements therein including a chip-  
16   level optical transceiver supported by a bench carried by the  
17   header in a tilted state aligning the chip-level optical  
18   transceiver components with the optical fiber.    Further still,  
19   this disclosure presents a method that includes providing an  
20   optical fiber, providing a bench that supports a chip-level  
21   optical transceiver, placing the bench in front of the optical  
22   fiber, activating the chip-level optical transceiver, and  
23   tilting the bench until the chip-level optical transceiver is

1 aligned with the optical fiber and an optical signal is  
2 achieved.

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4 Turning now to the drawings, in which like reference  
5 characters indicate corresponding elements throughout the  
6 several views, attention is first directed to FIG. 1, in which  
7 there is seen a simplified, vertical sectional view of a an  
8 integrated bi-directional transceiver package 100  
9 incorporating a tilted bench assembly 105 supporting chip-  
10 level optical transceiver components, in accordance with the  
11 principle of the invention. The chip-level optical components  
12 carried by bench assembly 105 are considered part of bench  
13 assembly 105. Package 100 incorporates a header 106, which is  
14 the underlying support for bench assembly 105. Header 106 has  
15 an inner face or surface 109 and an opposing outer face or  
16 surface 113. Surfaces 109 and 113 reside in spaced-apart,  
17 substantially parallel planes. Header 106 is fashioned of  
18 steel that is coated with gold plating of a predetermined  
19 thickness, although it can be constructed of another metal or  
20 combination of metals and/or metal composites, or from a non-  
21 metallic material such as co-fired ceramic, or other material  
22 or combination of materials capable of providing support for  
23 placement of bench assembly 105 as described below. Bench

1 assembly 105 is carried by header 106, and header 106  
2 constitutes the underlying support for bench assembly 105.  
3 Header 106 supports leads 112, which extend therethrough  
4 between surface 109 and surface 113, as illustrated. Leads  
5 112 are fashioned of conductive material, and provide  
6 electrical communication between the transceiver components of  
7 package 100 and external electrical components. Preferably,  
8 leads 112 are gold plated and are separated from header 106 by  
9 insulators, such as glass insulators. In a preferred  
10 embodiment, package 100 incorporates approximately eight  
11 leads. However, less or more can be used, if desired,  
12 including even one lead.

13

14 Header 106 supports a recess 110, which is formed therein  
15 through surface 109. In accordance with the invention, recess  
16 100 defines a ramp 110A, which is oriented at an angle  $\theta$  (FIG.  
17 2) relative to surface 109. Bench assembly 105 is held by  
18 recess 110, and is disposed against ramp 110A so as to reside  
19 in a tilted state, thus aligning its chip-level optical  
20 transceiver components in a tilted state. Ramp 110A is thus  
21 formed to receive and hold bench assembly 105, which carries  
22 transceiver components operable for emitting a wavelength of

1 light  $\lambda_1$  along an optical path 220. Bench assembly 105 is  
2 described in more detail below in conjunction with FIG. 2.

3

4 In the preferred embodiment disclosed herein, package 100  
5 includes a preamplifier 107 attached to surface 109, which is  
6 coupled in electrical communication to bench assembly 105 and  
7 lead 112. Preamplifier 107, which is an optical component,  
8 amplifies electrical signals from bench assembly 105.  
9 Preamplifier 107 can be omitted, if desired.

10

11 Package 100 incorporates an attached can structure 104,  
12 which overlies surface 109. Can structure 104 is attached to  
13 header 106, preferably to surface 109, and cooperates with  
14 header 106 to enclose bench assembly 105 and preamplifier 107.  
15 Can structure 104 provides hermetic sealing of bench assembly  
16 105 and preamplifier 107. Can structure 104 defines opposing  
17 openings 114 and 115, in which opening 114 is located  
18 proximate surface 109, and opening 115 is formed opposite  
19 surface 109 and is adapted and arranged to receive  
20 therethrough an optical fiber 101.

21

22 Bench assembly 105 is disposed in recess 110 and against  
23 ramp 110A, as previously mentioned, and, in accordance with

1 the invention, is optically aligned with, and thus optically  
2 coupled to, fiber 101. The tilt of bench assembly 105 as  
3 defined by angle  $\theta$ , as defined by ramp 110A, is in a range  
4 from approximately  $5^\circ$  to  $40^\circ$  relative to surface 109 of header  
5 106. In accordance with the invention, fiber 101 is thus  
6 optically aligned with bench assembly 105, in which the  
7 optical alignment is facilitated by the tilt of bench assembly  
8 105 relative to fiber 101.

9  
10 Optical fiber 101 extends into package 100, and is  
11 operative for transmitting a wavelength of light  $\lambda_2$  from a  
12 remote light source or transmitter. Optical fiber 101 is held  
13 in place by package 100, so as to be disposed therein, and  
14 through opening 115 of can structure 104, with a flange 103,  
15 which is part of package 100. Flange 103 is externally  
16 attached to can 104 proximate opening 115, such as by way of a  
17 selected adhesive or welding or solder or the like, encircles  
18 fiber 101, and supports fiber 101, thus holding it in place.  
19 Overlying flange 103 is a ferrule assembly 102, which is also  
20 part of package 100. Fiber 101 passes through, and is secured  
21 by, ferrule assembly 102. Ferrule assembly 102, flange 103  
22 and can structure 104 cooperate as a support structure for  
23 fiber 101, in which this defined support structure is attached

1 to header 106. Flange 103 can be considered part of can  
2 structure 104, if desired. Because header 106 is attached to  
3 can structure 104, header 106 can be considered part of, or  
4 otherwise an extension of, can structure 104 and, therefore,  
5 part of or otherwise an extension of the support structure as  
6 defined herein.

7  
8 Package 100 also incorporates an attached strain relief  
9 boot 108, which surrounds can structure 104, flange 103, and  
10 ferrule assembly 102, and also a portion of fiber 101  
11 extending upwardly from ferrule assembly 102. Strain relief  
12 boot 108 provides added support to package 100, and inhibits  
13 package 100 from becoming fractured or otherwise damaged as a  
14 result of turns or thrust abuse. Strain relief boot 108  
15 encloses can structure 104, flange 103, ferrule assembly 102,  
16 and the portion of fiber 101 extending into and through  
17 ferrule assembly 102 to within can structure 104.

18  
19 Looking to FIG. 2, bench assembly 105, which functions as  
20 a transceiver as previously mentioned, consists of a bench  
21 205, which, in accordance with the principle of the invention,  
22 supports chip-level optical transceiver components, namely,  
23 two photodiodes 201 and 204, a light emitting device 202, and

1 a lens 203. In a further and more particular aspect, the  
2 chip-level optical transceiver components of bench assembly  
3 105 function as a chip-level optical transceiver. Bench 205  
4 is elongate, is generally rectangular in shape, and, for the  
5 purpose of orientation in connection with the ensuing  
6 discussion, has opposing ends 205A and 205B, and opposing  
7 upper and lower surfaces 205C and 205D. Pockets or trenches  
8 225, 226, and 227, which are disposed between ends 205A and  
9 205B, and are formed into bench 205 through upper surface  
10 205C. Trench 225 is V-shaped and is disposed adjacent end  
11 205A. Trench 227 is also V-shaped, and is disposed adjacent  
12 end 205B. Trench 226 is generally V-shaped, and is disposed  
13 between trenches 225 and 226. Trenches 225, 226, and 227, are  
14 formed into bench 205, such as by way of etching (e.g., wet or  
15 dry etching), cutting, machining, etc. Bench 205 is  
16 integrally fashioned, and is constructed of silicon (Si), a  
17 low temperature co-fired ceramic, or a similar material or  
18 combination of materials that can be etched or otherwise cut  
19 to form trenches 225, 226, and 227. Photodiode 201 is carried  
20 by trench 225, lens 203 is carried by trench 226, photodiode  
21 204 is carried by trench 227, and light emitting device 202 is  
22 attached to upper surface 205C between trenches 225 and 226,  
23 and between photodiode 201 and lens 203.

1       Light emitting device 202 is operable for emitting light  
2   at wavelength  $\lambda_1$  along an optical path 220. Preferably, light  
3   emitting device 202 is an edge-emitting emitting semiconductor  
4   laser. However, light emitting device 202 can be a face-  
5   emitting semiconductor laser, or other desired form of laser-  
6   emitting device. Trenches 225, 226, and 227, are aligned on  
7   optical path 220.

8

9       Photodiode 201 is held in trench 225 and rests against a  
10   major surface 225A of trench 225, and is positioned or  
11   otherwise aligned so that it is able to detect light at  
12   wavelength  $\lambda_1$  emitted through end 230 of device 202 along  
13   optical path 220. Photodiode 201 controls the output of light  
14   emitting device 202, and this arrangement is well known in the  
15   art. End 230 of device 202 is directed toward photodiode 201.  
16   Lens 203 is held in trench 226, and is positioned to direct,  
17   e.g., collimate, light at wavelength  $\lambda_1$  emitted through end  
18   231 of device 202 to photodiode 204. Lens 203 is preferably a  
19   ball lens, although those of ordinary skill will appreciate  
20   that other lens forms can be used. Photodiode 204 is held in  
21   trench 227 and rests against a major surface 227A thereof, and  
22   is positioned or otherwise aligned so that it is able to  
23   detect light at wavelength  $\lambda_1$  from lens 203 along optical path



1 220. Photodiode 204 incorporates a dichroic filter 223,  
2 which, in the preferred embodiment disclosed herein, consists  
3 of an applied dichroic mirror, although it can consist of an  
4 applied thin film of dichroic material, if desired. Dichroic  
5 filter 223 defines an outer surface 222.  
6

7 As previously mentioned, optical fiber 101 transmits a  
8 wavelength of light  $\lambda_2$ , from a light source or transmitter,  
9 along optical path 221. Bench assembly 105 and fiber 101 are  
10 optically aligned so as to provide a peak optical signal, in  
11 which optical path 220 is coincident relative to optical path  
12 221. Light at wavelength  $\lambda_1$  from lens 203 along optical path  
13 220 is directed against dichroic filter 223 of photodiode 204,  
14 and is reflected therefrom into fiber 101 along optical path  
15 221. Light at wavelength  $\lambda_2$  from optical fiber 101 along  
16 optical path 221 is also directed toward dichroic filter 223  
17 of photodiode 204, and passes therethrough to an active region  
18 of photodiode 204 and is converted into an electrical signal.  
19

20 And so it is to be understood that dichroic filter 223,  
21 which is considered part of photodiode 204, is adapted and  
22 arranged to reflect wavelength of light  $\lambda_1$  into fiber 101  
23 along optical path 221, and to permit the wavelength of light

1  $\lambda_2$  along optical path 221 to pass therethrough photodiode 204  
2 to an active region thereof for conversion into an electrical  
3 signal. In one embodiment,  $\lambda_1$  can be 1310 nm and  $\lambda_2$  can be  
4 1550 nm. In another embodiment,  $\lambda_1$  can be 1550 nm and  $\lambda_2$  can  
5 be 1310 nm. It will be understood that 1310 nm and 1550 nm  
6 are wavelengths typically used in optical fiber communication  
7 systems. However, it will be understood that other  
8 wavelengths could be used, and that the use of 1310 nm and  
9 1550 nm in this disclosure is set forth as a matter of example  
10 and not by way of limitation.

11  
12 Surface 222 is oriented at an angle  $\phi$  relative to optical  
13 path 220 by tilting bench assembly 105 at a desired angle,  
14 namely, angle  $\theta$  as provided by ramp 110A, or, in accordance  
15 with an alternate embodiment, by choosing an angle  $\gamma$  of  
16 surface 227A of trench 227. Hence, light emitting device 202  
17 and fiber 101 can be optically aligned by choosing at least  
18 one of angles  $\theta$ ,  $\phi$ , and  $\gamma$ . In a preferred embodiment, optical  
19 paths 220 and 221 are optically aligned by disposing bench  
20 assembly 105 at a desired tilt or angle as defined by angle  $\theta$ ,  
21 in accordance with the principle of the invention.

1        In order to align optical fiber 101 with the chip-level  
2        optical transceiver of bench assembly 105 in accordance with  
3        an exemplary method of the invention, it is to be understood  
4        that optical fiber 101, and bench assembly 105 including bench  
5        205 and the attached chip-level optical transceiver  
6        components, are to be provided as disclosed herein. Bench 205  
7        is to be placed in front of optical fiber 101. The chip-level  
8        optical transceiver is activated so as to generate wavelength  
9        of light  $\lambda_1$  along optical path 220, and bench 205 is then  
10       tilted until the chip-level optical transceiver of bench  
11       assembly 105 is aligned with optical fiber 101 and an optical  
12       signal is achieved.

13  
14       Thus, an integrated bi-directional optical transceiver is  
15       disclosed, which is capable of transmitting and receiving data  
16       in an optical fiber, which can be used in a network and in  
17       other ways, namely, as a phase converter in a computer, and in  
18       other like applications. Also disclosed is a chip-level  
19       optical transceiver carried by a tilted bench for aligning the  
20       chip-level optical transceiver with an optical fiber, and a  
21       method of aligning a chip-level optical transceiver with an  
22       optical fiber. A bi-directional optical transceiver  
23       constructed in accordance with the principle of the invention

1 is easy to construct and inexpensive, and is capable of  
2 providing low cost and high power optical communication in a  
3 fiber to a network. Because the transceiver package disclosed  
4 herein incorporates a bench to which chip-level optical  
5 transceiver components are attached, a transceiver package  
6 constructed and arranged in accordance with the principle of  
7 the invention is highly compact, and very small, as compared  
8 to existing transceiver packages. The transceiver package  
9 disclosed herein allows bi-directional communication by using  
10 a dichroic filter positioned on a photodiode. The dichroic  
11 filter is chosen to allow the transmission of one wavelength  
12 of light while allowing the reflection of another wavelength  
13 of light.

14

15 The present invention is described above with reference  
16 to a preferred embodiment. Those skilled in the art will  
17 recognize that changes and modifications may be made in the  
18 described embodiment without departing from the nature and  
19 scope of the present invention. Various changes and  
20 modifications to the embodiment herein chosen for purposes of  
21 illustration will readily occur to those skilled in the art.  
22 To the extent that such modifications and variations do not  
23 depart from the spirit of the invention, they are intended to

1 be included within the scope thereof.

2

3 Having fully described the invention in such clear and  
4 concise terms as to enable those skilled in the art to  
5 understand and practice the same, the invention claimed is: